FORM PTO-1390 (REV. 1-98)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
0020-4783P

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)
09/719138 NEW

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/JP00/02300	April 10, 2000	April 8, 1999

PTO/PCT Rec'd 08 DEC 2000

TITLE OF INVENTION
HEAT-TRANSFER PIPE WITH INTERNAL GROOVES AND MANUFACTURING METHOD AND MANUFACTURING **

APPLICANT(S) FOR DO/EO/US
FUJINO, Hirokazu; KASAI, Kazushige; AKAI, Kanji; OKAMOTO, Noriaki; UCHIMITSU, Masaru

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39 (1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau. WO 00/62001
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(3)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(2)).
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.-1449 and International Search Report w/ cited documents
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:
    PCT/ISA/210
    Nine (9) sheets of formal drawings

**DEVICE THEREFOR

533 Rec'd PCT/PTO 06 DEC 2000

U.S. APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
NEW 09/719138	PCT/JP00/02300	0020-4783P

17. ☒ The following fees are submitted:

		CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5): Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO	**$1,000.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	**$860.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	**$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)	**$690.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)	**$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =		$ 860.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☒ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).		$ 130.00	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	CALCULATIONS	PTO USE ONLY
Total Claims	7 - 20 =	0	X $18.00	$ 0	
Independent Claims	3 - 3 =	0	X $80.00	$ 0	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)		NO	+ $270.00	$ 0	
TOTAL OF ABOVE CALCULATIONS =				$ 990.00	
Reduction of ½ for filing by small entity, if applicable. Verified Small Entity statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28).				$ 0	
SUBTOTAL =				$ 990.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$ 0	
TOTAL NATIONAL FEE =				$ 990.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ 0	
TOTAL FEES ENCLOSED =				$ 990.00	
				Amount to be: refunded	$
				charged	$

a. ☒ A check in the amount of $ 990.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account. No. __________ in the amount of $_______ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 02-2448.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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SIGNATURE

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REGISTRATION NO.

/rem D ecember 8, 2000

(REV. 09/29/2000)

09/719138

533 Rec'd PCT/PTO 08 DEC 2000

PATENT
0020-4783P

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicant: FUJINO, Hirokazu et al.

Int'l. Appl. No.: PCT/JP00/02300

Appl. No.: NEW Group:

Filed: December 8, 2000 Examiner:

For: HEAT-TRANSFER PIPE WITH INTERNAL GROOVES AND MANUFACTURING METHOD AND MANUFACTURING DEVICE THEREFOR

PRELIMINARY AMENDMENT

BOX PATENT APPLICATION
Assistant Commissioner for Patents
Washington, DC 20231

December 8, 2000

Sir:

The following Preliminary Amendments and Remarks are respectfully submitted in connection with the above-identified application.

AMENDMENTS

IN THE SPECIFICATION:

Please amend the specification as follows:

Before line 1, insert --This application is the national phase under 35 U.S.C. § 371 of PCT International Application No. PCT/JP00/02300 which has an International filing date of April 10, 2000, which designated the United States of America.--

Docket No. 0020-4783P

REMARKS

The specification has been amended to provide a cross-reference to the previously filed International Application.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

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JMS/rem
0020-4783P

(Rev. 04/19/2000)

9/PART

09/719138

533 Rec'd PCT/PTO 08 DEC 2000

Specification

HEAT-TRANSFER PIPE WITH INTERNAL GROOVES AND MANUFACTURING METHOD AND MANUFACTURING DEVICE THEREFOR

TECHNICAL FIELD

The present invention relates to a structure of a heat-transfer pipe with internal grooves having grooves in an inner surface of a pipe body.

BACKGROUND ART

A heat-transfer pipe in a heat exchanger such as an evaporator, a condenser or the like for an air conditioner is conventionally provided with spiral grooves in an inner surface of the pipe from a viewpoint of improvement in its heat transfer efficiency as shown in Japanese Patent Laid-Open Publication No. Hei 9-42881 so that a heat-transfer area is enlarged and an agitation effect is improved by allowing a refrigerant flowing in the pipe to annularly flow.

In the case of a heat-transfer pipe in this constitution, however, liquid film portions are uniformly distributed generally in the pipe when a condensation action proceeds to some extent and the thickness gradually

increases. Consequently, heat resistance and diffusion resistance increase and thereby a heat-transfer performance is deteriorated.

In order to address this problem, there is a proposal that the inner surface of the pipe is divided into a plurality of areas in the circumferential direction, each having a plurality of rows of grooves arranged in V-shaped patterns, for example, which are symmetric with respect to the direction of a pipe axis and have equal widths in the circumferential direction, for example, as shown in Japanese Patent Laid-Open Publication No. Hei 9-42880.

In the case of this constitution, the distribution of the refrigerant flowing in the pipe in the pipe circumferential direction can be made ununiform because of flow merging and dividing actions by the plurality of the grooves arranged in V-shaped patterns provided in the inner surface of the pipe which are symmetric with respect to the pipe axis direction and have equal widths in the circumferential direction as compared with the aforementioned heat-transfer pipe having the spiral grooves. Since high heat transfer efficiency is achieved in areas where the liquid refrigerant becomes a thin film as a result, the heat transfer efficiency at the time of condensation is improved.

However, in the case of the above-described

heat-transfer pipe having grooves arranged in V-shaped patterns in the inner surface of the pipe which are symmetric with respect to the pipe axis direction and have equal widths in the circumferential direction,

1. Since refrigerant flows are collided and merged due to the grooves arranged in V-shaped patterns, flow resistance is high. For example, in the case where this heat-transfer pipe is used as an evaporator or the like, sufficient improvement of the heat transfer performance, which is affected by a great pressure loss, can not necessarily be obtained.

2. In areas where a refrigerant flow rate is low (areas having little refrigerant circulation), there is little effect even though the refrigerant distribution is made ununiform by the grooves arranged in V-shaped patterns. In the case where the heat-transfer pipe is used as an evaporator, in particular, a heat transfer performance enhancing effect cannot be obtained since a sufficient liquid refrigerant cannot be supplied in the pipe circumferential direction due to the groove structure. That is, improvement of the performance cannot be expected in some use areas.

DISCLOSURE OF THE INVENTION

An object of the present invention is to provide

a heat-transfer pipe with internal grooves having a heat transfer performance improved as much as possible by reducing a pressure loss and appropriately controlling refrigerant flows in the pipe to be even when a refrigerant flow rate is low, and a manufacturing method thereof as well as a manufacturing device, by which the above-described problems can be solved.

In order to achieve the above object, each aspect of the present invention has the following means for solving the problems.

(I) First aspect of the invention

In a heat-transfer pipe with internal grooves according to the first aspect of the present invention, a plurality of rows of grooves arranged in V-shaped patterns 3 symmetric with respect to a pipe axis direction are provided on an inner surface 2 of a pipe body 1a; and widths of the plurality of rows of the grooves 3 arranged in the V-shaped patterns are made unequal in a circumferential direction.

Thus, when the plurality of rows of the grooves 3 arranged in V-shaped patterns are provided side by side with unequal widths in the circumferential direction, a component of force in the swirling direction are generated in a refrigerant liquid so that the refrigerant liquid flows in an ununiform manner in the pipe axis direction while repeatedly merging and dividing at edges of respective

grooves 3 arranged in the V-shaped patterns. Consequently, an annular flow close to the one obtained by combination of spiral grooves can be obtained. Further, an agitation effect is achieved and thereby a heat transfer performance is improved.

(II) Second aspect of the invention

In the heat-transfer pipe with internal grooves according to the second aspect of the present invention, secondary grooves 6 having a prescribed depth are formed from a top 5a side towards a base 5b side at least in part of projected portions 5 formed between respective grooves 3 of the plurality of rows of the grooves 3 arranged in the V-shaped patterns.

Thus, when the secondary grooves 6 having a prescribed depth are formed from the top part 5a side towards the bottom part 5b side at least in part of the projected portions 5 formed between the respective grooves 3 of the plurality of rows of the grooves 3 arranged in V-shaped patterns, the flow resistance of the refrigerant flowing in the pipe is further reduced by the secondary grooves 6 and thereby a heat transfer performance is effectively improved even when a refrigerant flow rate is low.

(III) Third aspect of the invention

In the heat-transfer pipe with internal grooves

according to the third aspect of the present invention, the secondary grooves 6 are notched grooves in a spiral direction.

In this case, the flow resistance of the refrigerant flowing in the pipe is effectively reduced by the secondary grooves 6 composed of the notched grooves in the spiral direction. Further, a swirling force is increased in the spiral direction and thereby the heat transfer performance is improved.

(IV) Fourth aspect of the invention

In the heat-transfer pipe with internal grooves according to the fourth aspect of the present invention, secondary grooves 7 having a prescribed depth are formed in an outer surface of at least part of projected portions 5 formed between respective grooves 3 of the rows of grooves 3 arranged in the V-shaped patterns.

Thus, when the secondary grooves 7 having a prescribed depth are formed in outer surfaces at least in part of the projected portions 5 formed between the respective grooves 3 of the rows of grooves arranged in the V-shaped patterns, a pressure loss is reduced since the flow resistance of the refrigerant flowing in the pipe is reduced by the secondary grooves 7 and thereby a heat transfer performance is effectively improved even when a refrigerant flow rate is low.

(V) Fifth aspect of the invention

In the heat-transfer pipe with internal grooves according to the fifth aspect of the present invention, the secondary grooves 7 are fine grooves extending from one side surface of the projected portions 5 to the other side surface thereof.

The flow resistance of the refrigerant flowing in the pipe is effectively reduced by the secondary grooves 7 composed of fine grooves extending from one side surface to the other side surface of the projected portions 5 in this case, and therefore the heat transfer performance is improved. Also, even when the pipe is expanded, both sides of the fine grooves are not crushed and thereby the heat-transfer performance is not deteriorated.

(VI) Sixth aspect of the invention

In a method for manufacturing a heat-transfer pipe with internal grooves according to the sixth aspect of the present invention, a first marking roll 11 for marking a plurality of rows of grooves 3 arranged in V-shaped patterns in a flat plate-like heat-transfer pipe material 13, a second marking roll 12 for marking secondary grooves 7 at least in part of projected portions 5 formed between respective grooves 3 of the plurality of rows of the grooves 3 arranged in the V-shaped patterns and a roll forming device 17 for forming the flat plate-like heat-transfer pipe

material 13 into a cylindrical pipe are used to continuously mark the plurality of rows of the grooves 3 arranged in the V-shaped patterns and the secondary grooves 7 in the flat plate-like heat-transfer pipe material 13 successively by the first and second marking rolls 11, 12 and then form a cylindrical pipe by roll forming by the roll forming device 17.

In this method of manufacturing a heat-transfer pipe with internal grooves, the heat-transfer pipe with internal grooves having the constitutions of the first, fourth and fifth aspects can be easily manufactured only by combining the above-described first and second marking rolls 11, 12 in the direction of the movement of the flat plate-like heat-transfer pipe material 13 to perform continuous markings successively in two stages.

(VII) Seventh aspect of the invention

In a device for manufacturing a heat-transfer pipe with internal grooves according to the seventh aspect of the present invention, a first marking roll 11 for marking a plurality of rows of grooves 3 arranged in V-shaped patterns in a flat plate-like heat-transfer pipe material 13, a second marking roll 12 for marking secondary grooves 7 at least in part of projected portions 5 formed between respective grooves 3 of the plurality of rows of the grooves 3 arranged in V-shaped patterns and a roll forming

device 17 for forming the flat plate-like heat-transfer pipe material 13 into a cylindrical pipe are provided successively side by side in a direction of movement of the flat plate-like heat-transfer pipe material 13 to continuously mark the grooves 3 arranged in the V-shaped patterns and the secondary grooves 7 successively by the first and second marking rolls 11, 12 and then form a cylindrical pipe by roll forming by the roll forming device 17.

By this device for manufacturing the heat-transfer pipe with internal grooves, the heat-transfer pipe with internal grooves having the constitutions of the first, fourth and fifth aspects can be easily manufactured only by combining the above-described first and second marking rolls 11, 12 in the direction of the movement of the flat plate-like heat-transfer pipe material 13 to perform markings successively in two stages.

As a result of the above, according to the heat-transfer pipe with internal grooves and the manufacturing method thereof and the manufacturing device according to each aspect of the present invention, a pressure loss, heat resistance in the heat-transfer pipe and diffusion resistance are reduced even in the case of being constituted as a condenser or an evaporator or even in the case where a refrigerant flow rate is low when the pipe is constituted as

an evaporator. Consequently, a heat exchanger with sufficiently high heat transfer performance can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an enlarged view showing part of a structure in an opened state of a pipe body of a heat-transfer pipe with internal grooves according to a first embodiment of the present invention;

Fig. 2 is an enlarged view of an essential part of the inner surface of the pipe body;

Fig. 3 is a perspective view of a cut-off section of the essential part of the inner surface of the pipe body;

Fig. 4 is an enlarged view showing a structure of an essential part of the inner surface of a pipe body of a heat-transfer pipe with internal grooves according to a second embodiment of the present invention;

Fig. 5 is an enlarged perspective view of the essential part;

Fig. 6 is a perspective view of a cut-off section of the essential part of the inner surface of the pipe body;

Fig. 7 is an enlarged view showing a structure of an essential part of the inner surface of a pipe body of a heat-transfer pipe with internal grooves according to a

third embodiment of the present invention;

Fig. 8 is an enlarged perspective view of a cut-off section of the essential part; and

Fig. 9 is a perspective view showing manufacture of a heat-transfer pipe with internal grooves according to the third embodiment of the present invention and a constitution of a manufacturing device.

BEST MODE FOR CARRYING OUT THE INVENTION

First Embodiment

Figs. 1 to 3 show a structure of a heat-transfer pipe with internal grooves according to a first embodiment of the present invention.

First, as shown in Figs. 1 to 3 for example, in the heat-transfer pipe 1 with internal grooves according to this embodiment, first to fifth groups A - E of a plurality of rows of grooves is provided on an inner surface 2 of a pipe body 1a having an electric welded pipe structure. Those groups of grooves are comprised of grooves 3 which are arranged to be symmetric with respect to a pipe axis direction and to form relatively sharp V-shape patterns, and which are arranged with width of the grooves unequal to each other in the circumferential direction and with a lead angle θ of the grooves different from each other, so as to promote a turbulent flow of a refrigerant liquid flowing in the pipe

body 1a and to promote the refrigerant liquid to become a thin film because coarse and minute refrigerant liquid portions are formed by dividing and merging the refrigerant liquid flow.

In Fig. 3, reference numeral 5 denotes a projected portion formed between the respective grooves 3 arranged in V-shaped patterns. Reference numerals 5a and 5b denote a top and a base of the projected portion, respectively.

Thus, since the first to fifth groups A - E composed of rows of grooves, which are arranged in V-shaped patterns and have a lead angle θ different in next groups, are provided side by side with unequal widths in the circumferential direction, the refrigerant liquid flows ununiformly in the circumferential direction to swirl while repeatedly dividing and merging at edge portions of V-shape patterns of the respective grooves 3. Consequently, the grooves of the present invention can obtain an annular flow close to the one conventionally obtained by combination of spiral grooves even though the grooves arranged in V-shaped patterns are used. Thus, an effective agitation effect is achieved and thereby a heat transfer performance is improved.

Respective grooves 3 in the first to fifth groups A - E are formed with a prescribed lead angle θ, a prescribed depth H and a prescribed number of grooves N so

that the flow resistance of each groove portion is made as small as possible to reduce the pressure loss. Therefore, even when the heat-transfer pipe of the present invention is used for an evaporator at a low refrigerant flow rate, the pressure loss is reduced and thereby the heat transfer performance is improved.

According to the results of experiments conducted by the present inventors, the flow resistance was the smallest and the pressure loss was effectively reduced when the aforementioned lead angle θ, groove depth H, and number of grooves N are in the range of 5 - 15°, 0.2 - 0.3 mm and 45 - 55, respectively, in the case of a heat-transfer pipe having an outer dimension of ϕ = 7 mm.

As described above, according to the constitution of the heat-transfer pipe with internal grooves of this embodiment, widths of groups A - E composed of rows of grooves 3, which are arranged in V-shaped patterns and have a lead angle θ different from each other, are set unequal in the circumferential direction rather than equal. Therefore, the refrigerant in the pipe has swirling flow as in the case of the conventional pipe with spiral grooves. Consequently, the heat transfer promotion effect is not deteriorated even when a refrigerant flow rate is low because the refrigerant is effectively supplied in the circumferential direction of the pipe.

The lead angle θ, the groove depth H and the groove number N of the grooves 3 formed in the V-shaped patterns, the first to fifth groups A - E of which are arranged in the inner surface of the pile, are set to the values by which the smallest flow resistance is obtained corresponding to the aforementioned experiment results. Therefore, since the flow resistance can be made as small as possible to reduce the pressure loss as a result, a heat-transfer pipe for a heat exchanger having a sufficiently high performance can be obtained.

Second Embodiment

Figs. 4 to 6 show a structure of a heat-transfer pipe with internal grooves according to a second embodiment of the present invention.

First, in the heat-transfer pipe 1 with internal grooves according to this embodiment, first to fifth groups A - E of a plurality of rows of grooves is provided on an inner surface 2 of a pipe body 1a having the same electric welded pipe structure as described above. Those groups of grooves are comprised of grooves 3 which are arranged to be symmetric with respect to a pipe axis direction and to form relatively sharp V-shape patterns, and which are arranged with width of the grooves unequal to each other in the circumferential direction and with a lead angle θ of the grooves different from each other, so as to promote a

turbulent flow of a refrigerant liquid flowing in the pipe body 1a and to promote the refrigerant liquid to become a thin film because coarse and minute refrigerant liquid portions are formed by dividing and merging the refrigerant liquid flow.

In Figs. 5 and 6, reference numeral 5 denotes a projected portion formed between the respective grooves 3 arranged in V-shaped patterns. Reference numerals 5a and 5b denote a top and a base of the projected portion 5, respectively. In this embodiment, secondary grooves 6 are provided and the secondary grooves 6 are composed of notched grooves (chipped grooves) in the spiral direction with a prescribed depth d from the top 5a towards the base 5b. Consequently, the flow resistance of the refrigerant is reduced and the refrigerant is further urged in the swirling direction.

Thus, since the first to fifth groups A - E composed of rows of grooves, which are arranged in V-shaped patterns and have a lead angle θ different in next groups, are provided side by side with unequal widths in the circumferential direction, the refrigerant liquid flows ununiformly in the circumferential direction to swirl while repeatedly dividing and merging at edge portions of V-shape patterns of the respective grooves 3. Consequently, the grooves of the present invention can obtain an annular flow

close to the one conventionally obtained by combination of spiral grooves even though the grooves arranged in V-shaped patterns are used. Thus, an effective agitation effect is achieved and thereby a heat transfer performance is improved.

Respective grooves 3 in the first to fifth groups A - E are formed with the secondary grooves 6 composed of notched grooves (chipped grooves) in the spiral direction as described above as well as a prescribed lead angle θ, a prescribed depth H and a prescribed number of grooves as in the first embodiment, so that the flow resistance of each groove portion is made as small as possible to reduce the pressure loss. Therefore, even when the heat-transfer pipe of the present invention is used for an evaporator at a low refrigerant flow rate, the pressure loss is reduced and thereby the heat transfer performance is improved.

According to the results of experiments conducted by the present inventors as described above, the flow resistance was the smallest and the pressure loss was effectively reduced when the aforementioned lead angle θ, groove depth H, and number of grooves N are in the range of 5 - 15°, 0.2 - 0.3 mm and 45 - 55, respectively, in the case of a heat-transfer pipe having an outer dimension of ϕ = 7 mm.

As described above, according to the

constitution of the heat-transfer pipe with internal grooves of this embodiment, widths of groups A - E composed of rows of grooves 3, which are arranged in V-shaped patterns and have a lead angle θ different from each other, are set unequal in the circumferential direction. Therefore, the refrigerant in the pipe has swirling flow as in the case of the conventional pipe with spiral grooves. Consequently, the heat transfer promotion effect is not deteriorated even when a refrigerant flow rate is low because the refrigerant is effectively supplied in the circumferential direction of the pipe.

The lead angle θ, the groove depth H and the groove number N of the grooves 3 formed in the V-shaped patterns, the first to fifth groups A - E of which are arranged in the inner surface of the pile, are set to the values by which the smallest flow resistance is obtained. In addition, the secondary grooves 6 are formed in the projected portions 5 provided between the respective grooves 3 as main grooves in V-shaped patterns and the secondary grooves 6 are notched grooves from the top 5a towards the base 5b of the projected portions 5 and are directed in the spiral direction. Therefore, since the flow resistance can be made as small as possible to reduce the pressure loss and swirling force in the spiral direction can be further increased, a heat-transfer pipe for a heat exchanger having

a still higher performance can be obtained.

Third Embodiment

Figs. 7 to 9 show a structure of a heat-transfer pipe with internal grooves according to a third embodiment of the present invention and a constitution of a manufacturing device employing a method for manufacturing the heat-transfer pipe, respectively.

First, in the heat-transfer pipe 1 with internal grooves according to this embodiment, first to fifth groups A - E of a plurality of rows of grooves is provided on an inner surface 2 of a pipe body 1a having the same electric welded pipe structure as described above. Those groups of grooves are comprised of grooves 3 which are arranged to be symmetric with respect to a pipe axis direction and to form relatively sharp V-shape patterns, and which are arranged with width of the grooves unequal to each other in the circumferential direction and with a lead angle θ of the grooves different from each other, so as to promote a turbulent flow of a refrigerant liquid flowing in the pipe body 1a and to promote the refrigerant liquid to become a thin film because coarse and minute refrigerant liquid portions are formed by dividing and merging the refrigerant liquid flow.

In Figs. 7 and 8, reference numeral 5 denotes a projected portion formed between the respective grooves 3

arranged in V-shaped patterns. Reference numerals 5a and 5b denote a top and a base of the projected portion 5, respectively. In this embodiment, secondary grooves 7 composed of fine grooves having a prescribed depth are formed from one side of an outer surface of the projected portion 5 to the other side thereof to direct toward, for example, the spiral direction. Consequently, the flow resistance of the refrigerant is reduced and the refrigerant is further urged in the swirling direction.

Thus, since the first to fifth groups A - E composed of rows of grooves, which are arranged in V-shaped patterns and have a lead angle θ different in next groups, are provided side by side with unequal widths in the circumferential direction, the refrigerant liquid flows ununiformly in the circumferential direction to swirl while repeatedly dividing and merging at edge portions of V-shape patterns of the respective grooves 3. Consequently, the grooves of the present invention can obtain an annular flow close to the one conventionally obtained by combination of spiral grooves even though the grooves arranged in V-shaped patterns are used. Thus, an effective agitation effect is achieved and thereby a heat transfer performance is improved.

Respective grooves 3 in the first to fifth groups A - E are formed with the secondary fine grooves 7 formed from one side of an outer surface of the projected

portion 5 to the other side thereof in a prescribed depth to direct toward the spiral direction as well as with a prescribed lead angle θ, a prescribed depth H and a prescribed number of grooves as in the first embodiment. Consequently, the flow resistance of each groove portion is made as small as possible to reduce the pressure loss. Therefore, even when the heat-transfer pipe of the present invention is used for an evaporator at a low refrigerant flow rate, the pressure loss is reduced and thereby the heat transfer performance is improved. Also, even when the pipe is expanded, the fine grooves on the side portions are not crushed and thereby the heat transfer performance is not deteriorated.

According to the results of experiments conducted by the present inventors as described above, the flow resistance was the smallest and the pressure loss was effectively reduced when the aforementioned lead angle θ, groove depth H, and number of grooves N are in the range of 5 - 15°, 0.2 - 0.3 mm and 45 - 55, respectively, in the case of a heat-transfer pipe having an outer dimension of $\phi \doteq 7$ mm.

As described above, according to the constitution of the heat-transfer pipe with internal grooves of this embodiment, widths of groups A - E composed of rows of grooves 3, which are arranged in V-shaped patterns and

have a lead angle θ different from each other, are set unequal. Therefore, the refrigerant in the pipe has swirling flow as in the case of the conventional pipe with spiral grooves. Consequently, the heat transfer promotion effect is not deteriorated even when a refrigerant flow rate is low because the refrigerant is effectively supplied in the circumferential direction of the pipe.

The lead angle θ, the groove depth H and the groove number N of the grooves 3 formed in the V-shaped patterns, the first to fifth groups A - E of which are arranged in the inner surface of the pile, are set to the values by which the smallest flow resistance is obtained. In addition, the secondary grooves 7 composed of fine grooves are formed from one side of an outer surface of the projected portion 5 to the other side thereof to direct toward, for example, the spiral direction. Therefore, since the flow resistance can be made as small as possible to reduce the pressure loss and swirling force in the spiral direction can be further increased, a heat-transfer pipe for a heat exchanger having a still higher performance can be obtained. Also, even when the pipe is expanded, the fine grooves on the side portions are not crushed and thereby the heat transfer performance is not deteriorated.

The heat-transfer pipe with internal grooves

having the groups A - E of rows of the grooves arranged in V-shaped patterns and secondary grooves 7 described above are easily manufactured by the following method by using, for example, a manufacturing device shown in Fig. 9.

In Fig. 9, reference numeral 11 denotes a first marking roll which has a marking processing surface 11a corresponding to the first to fifth groups A - E of rows of grooves arranged as main grooves in V-shaped patterns. Reference numeral 12 denotes a second marking roll which has a marking processing surface 12a for marking the fine grooves 7 provided to extend, for example, in the spiral direction from one side to the other side of an outer surface of the projected portion 5 formed between the grooves 3 arranged in V-shaped patterns in the first to fifth groups A - E. Reference numeral 13 denotes a flat plate-like heat-transfer pipe material. Reference numeral 16 denotes a heating device for heating and softening the heat-transfer pipe material at the time of roll forming. Reference numeral 14 denotes a first pressure roller for sandwiching and pressing the flat plate-like heat-transfer pipe material 13 with the aforementioned first marking roll 11. Reference numeral 15 denotes a second pressure roller for sandwiching and pressing the flat plate-like heat-transfer pipe material 13 with the aforementioned second marking roll 12. Reference numeral 17 denotes a roll

forming device having a roll forming hole 17a for roll-forming into a cylindrical shape the heat-transfer pipe material 13 which has the first to fifth groups A - E of rows of grooves arranged in V-shaped patterns and the secondary grooves 7 formed thereon via the first and second marking rollers 11, 12 and is heated and softened by the heating device 16. The first marking roll 11 and the first pressure roller 14, the second marking roll 12 and the second pressure roller 15, the heating device 16 and the roll forming device 17 are successively provided side by side at predetermined intervals in the movement direction (see the arrow) of the heat-transfer pipe material 13.

Therefore, in the device for manufacturing the heat-transfer pipe with internal grooves, the first marking roll 11 and the first pressure roller 14 are used for marking the first to fifth groups A - E of rows of grooves arranged in V-shaped patterns, the second marking roll 12 and the second pressure roller 15 are used for marking the secondary grooves 7 in part of the projected portions formed between the respective grooves 3 of the first to fifth groups A - E of rows of grooves arranged in V-shaped patterns, and the heating device 16 and the roll forming device 17 are used for forming the flat plate-like heat-transfer pipe material 13 into a cylindrical pipe. The first and second marking rolls 11, 12 are rotatably operated

so that the respective grooves 3 of the first to fifth groups A - E and the secondary grooves 7 are successively marked in two stages on the flat plate-like heat-transfer pipe material 13, and then the heat-transfer pipe material 13 can be heated and softened by the heating device 16 and then roll-formed by the roll forming device 17 to form a cylindrical pipe.

That is, in the method and device for manufacturing the heat-transfer pipe with internal grooves, the heat-transfer pipe with internal grooves having a constitution shown in Figs. 7 and 8 can be easily manufactured only by two stage successive marking of the grooves with the above-described first and second marking rolls 11, 12 combined in the direction of the movement of the flat plate-like heat-transfer pipe material 13.

Other Embodiments

Although a heat-transfer pipe of a electric welded pipe type is described as an example in the above embodiments, it is needless to say that the internal groove structures of the above embodiments can be also applied to a seam welded type of heat-transfer pipe.

INDUSTRIAL APPLICABILITY

As described above, the heat-transfer pipe with internal grooves and the manufacturing method thereof and

the manufacturing device according to the present invention are useful for a heat-transfer pipe of a heat exchanger and particularly suitable for a heat-transfer pipe used for an evaporator or a condenser in an air-conditioner.

CLAIMS:

1. A heat-transfer pipe with internal grooves, wherein

a plurality of rows of grooves arranged in V-shaped patterns (3) symmetric with respect to a pipe axis direction are provided on an inner surface (2) of a pipe body (1a); and

widths of the plurality of rows of the grooves (3) arranged in the V-shaped patterns are made unequal in a circumferential direction.

2. The heat-transfer pipe with internal grooves according to claim 1, wherein

secondary grooves (6) having a prescribed depth are formed from a top (5a) side towards a base (5b) side at least in part of projected portions (5) formed between respective grooves (3) of the plurality of rows of the grooves (3) arranged in the V-shaped patterns.

3. The heat-transfer pipe with internal grooves according to claim 2, wherein

the secondary grooves (6) are notched grooves in a spiral direction.

4. The heat-transfer pipe with internal grooves according to claim 1, wherein

secondary grooves (7) having a prescribed depth are formed in an outer surface of at least part of projected

portions (5) formed between respective grooves (3) of the rows of grooves (3) arranged in the V-shaped patterns.

5. The heat-transfer pipe with internal grooves according to claim 4, wherein

the secondary grooves (7) are fine grooves extending from one side surface of the projected portions (5) to the other side surface thereof.

6. A method for manufacturing a heat-transfer pipe with internal grooves, wherein

a first marking roll (11) for marking a plurality of rows of grooves (3) arranged in V-shaped patterns in a flat plate-like heat-transfer pipe material (13), a second marking roll (12) for marking secondary grooves (7) at least in part of projected portions (5) formed between respective grooves (3) of the plurality of rows of the grooves (3) arranged in the V-shaped patterns and a roll forming device (17) for forming the flat plate-like heat-transfer pipe material (13) into a cylindrical pipe are used to continuously mark the plurality of rows of the grooves (3) arranged in the V-shaped patterns and the secondary grooves (7) in the flat plate-like heat-transfer pipe material (13) successively by the first and second marking rolls (11), (12) and then form a cylindrical pipe by roll forming by the roll forming device (17).

7. A device for manufacturing a heat-transfer pipe

with internal grooves, wherein

a first marking roll (11) for marking a plurality of rows of grooves (3) arranged in V-shaped patterns in a flat plate-like heat-transfer pipe material (13), a second marking roll (12) for marking secondary grooves (7) at least in part of projected portions (5) formed between respective grooves (3) of the plurality of rows of the grooves (3) arranged in V-shaped patterns and a roll forming device (17) for forming the flat plate-like heat-transfer pipe material (13) into a cylindrical pipe are provided successively side by side in a direction of movement of the flat plate-like heat-transfer pipe material (13) to continuously mark the grooves (3) arranged in the V-shaped patterns and the secondary grooves (7) successively by the first and second marking rolls (11), (12) and then form a cylindrical pipe by roll forming by the roll forming device (17).

ABSTRACT

A pressure loss is reduced by providing a plurality of rows of grooves (3) arranged in V-shaped patterns on an inner surface of a pipe body (1a) so as for the rows of grooves to be symmetric with respect to the pipe axis direction and by forming secondary grooves (6), (7) in a prescribed depth in part of projected portions (5) formed therebetween. Also, even when a refrigerant flow rate is low, the refrigerant flow in the pipe can be appropriately controlled by making widths of the plurality of rows of the grooves (3) arranged in the V-shaped patterns unequal in the circumferential direction to generate swirl in the spiral direction and thereby a heat transfer performance is improved as much as possible.

Fig.1

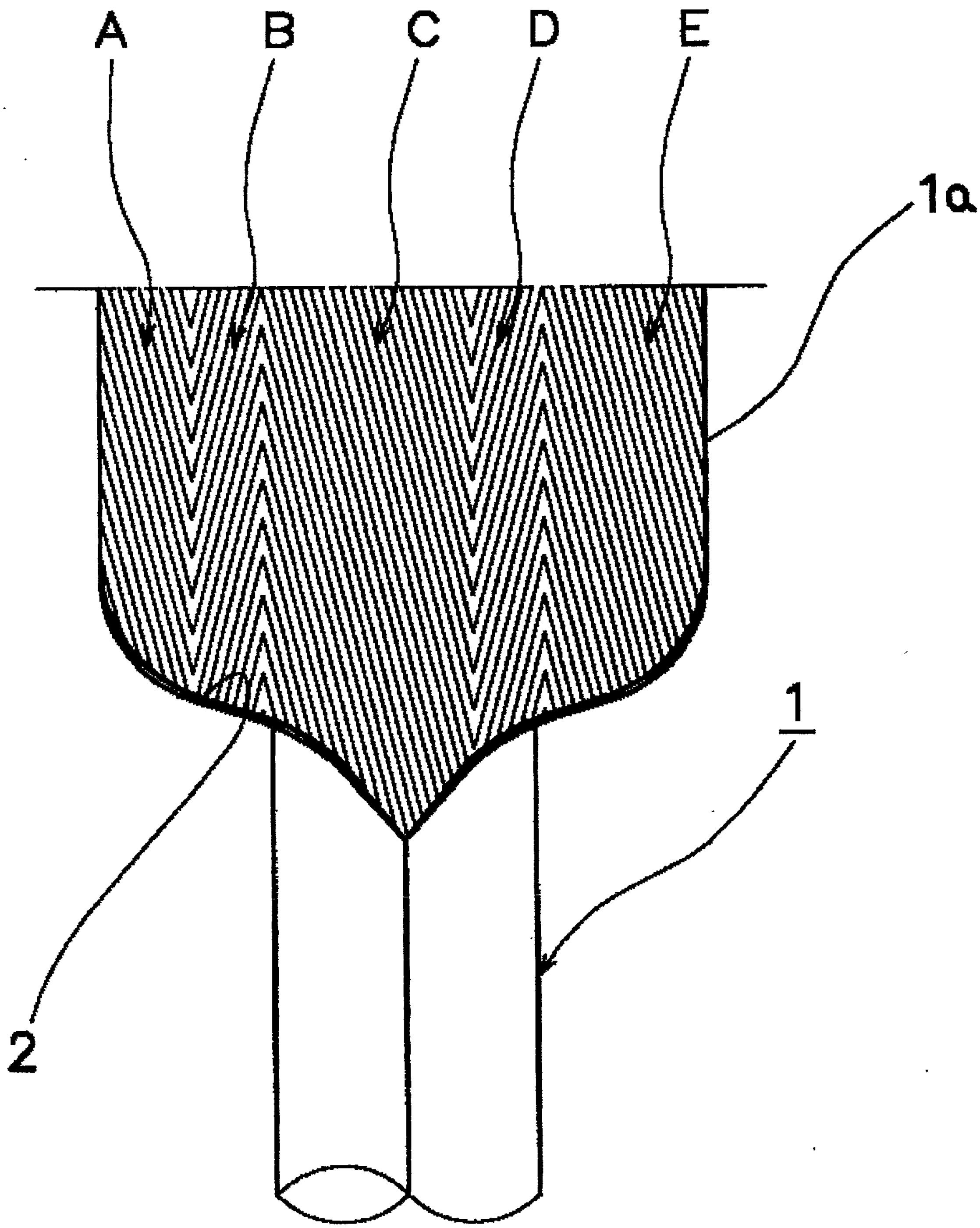


Fig.2

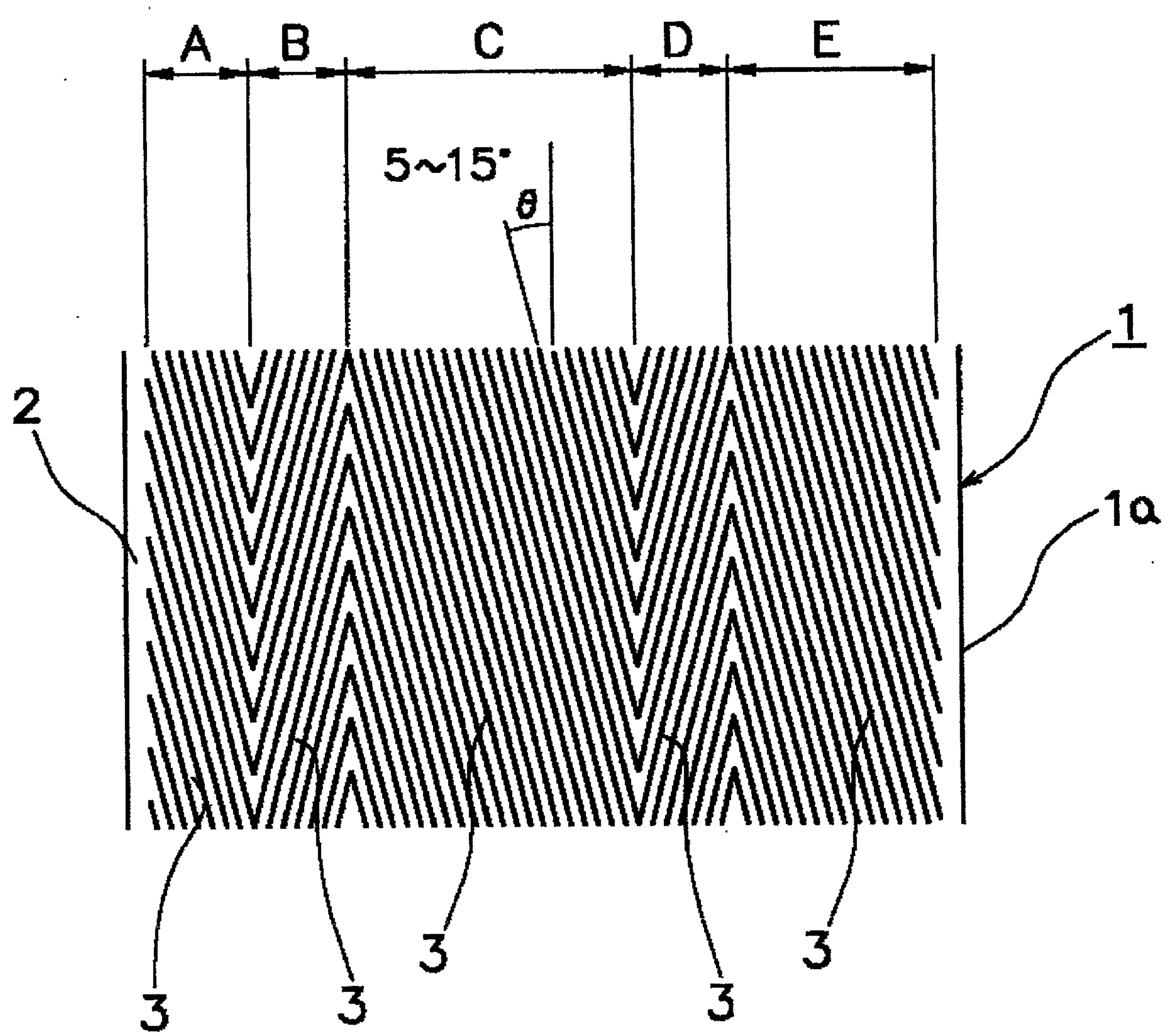


Fig. 3

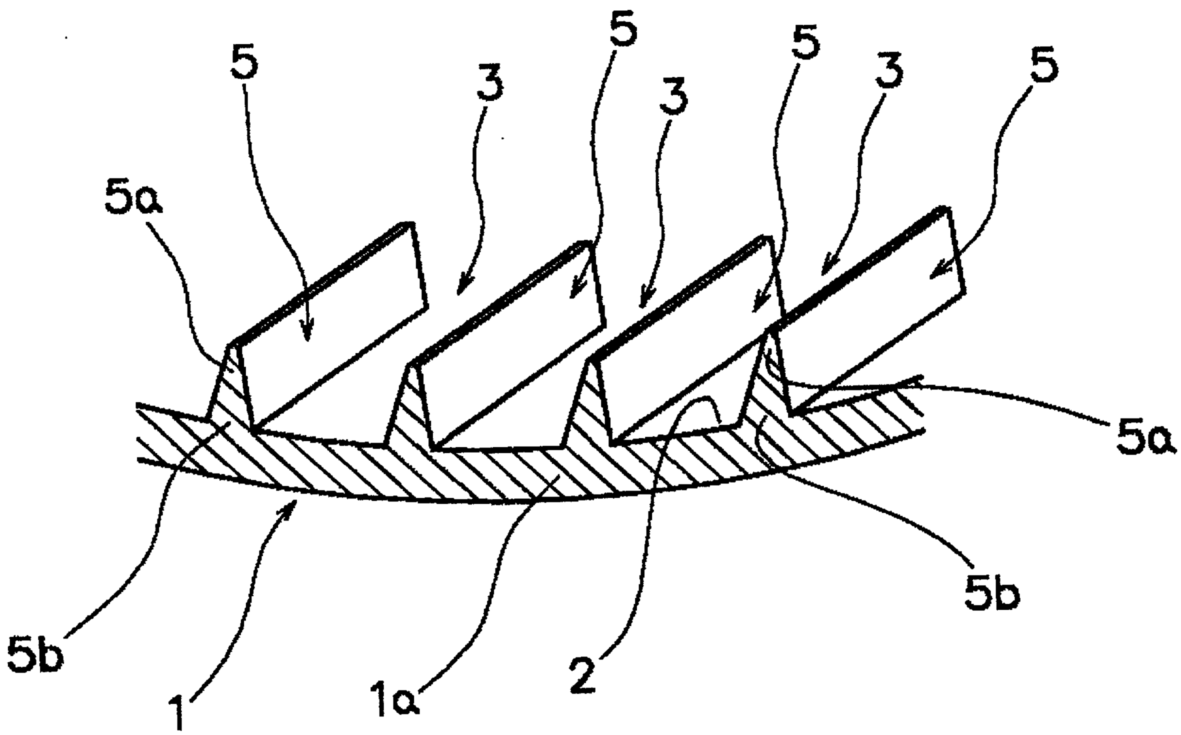


Fig.4

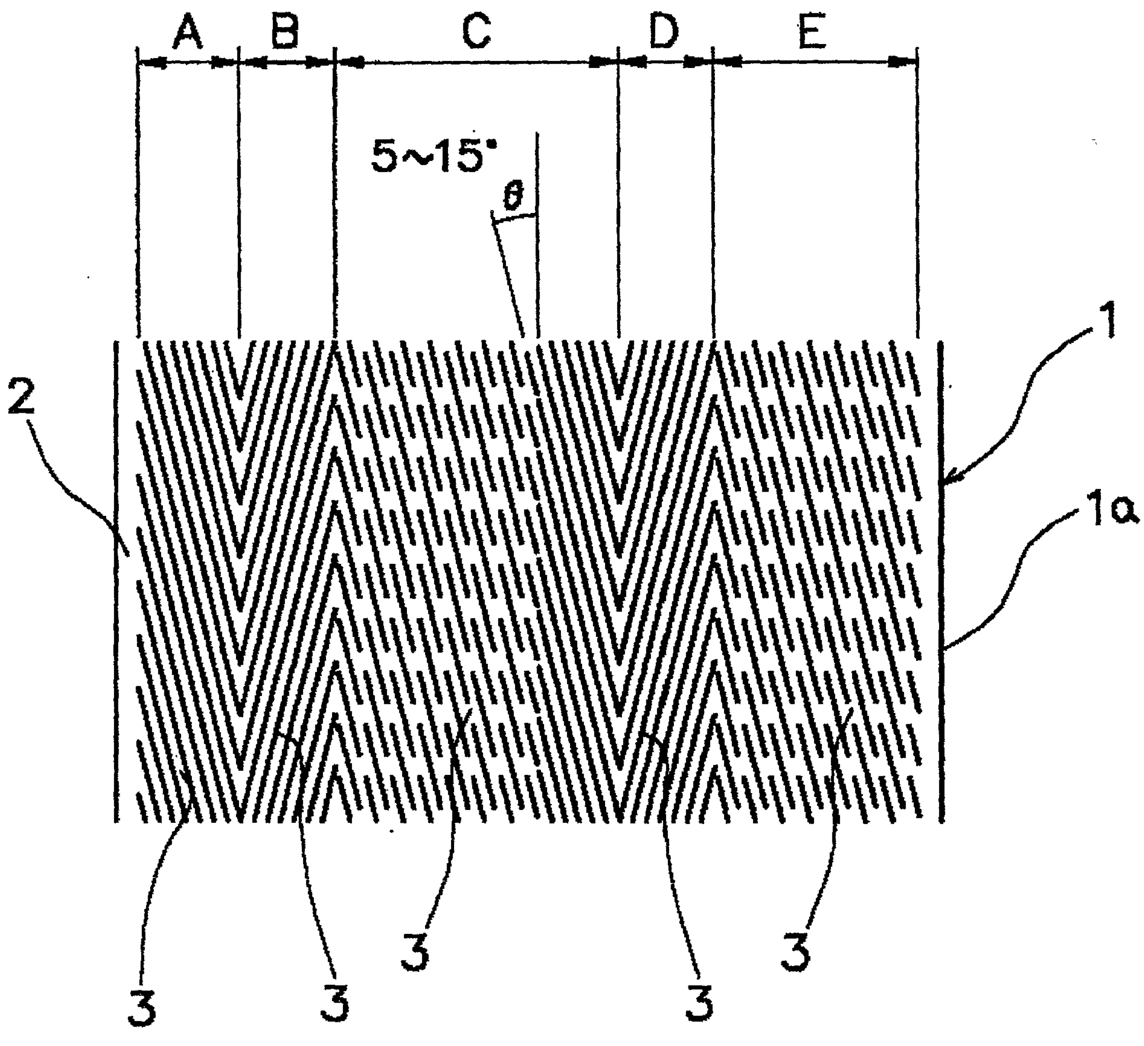


Fig. 5

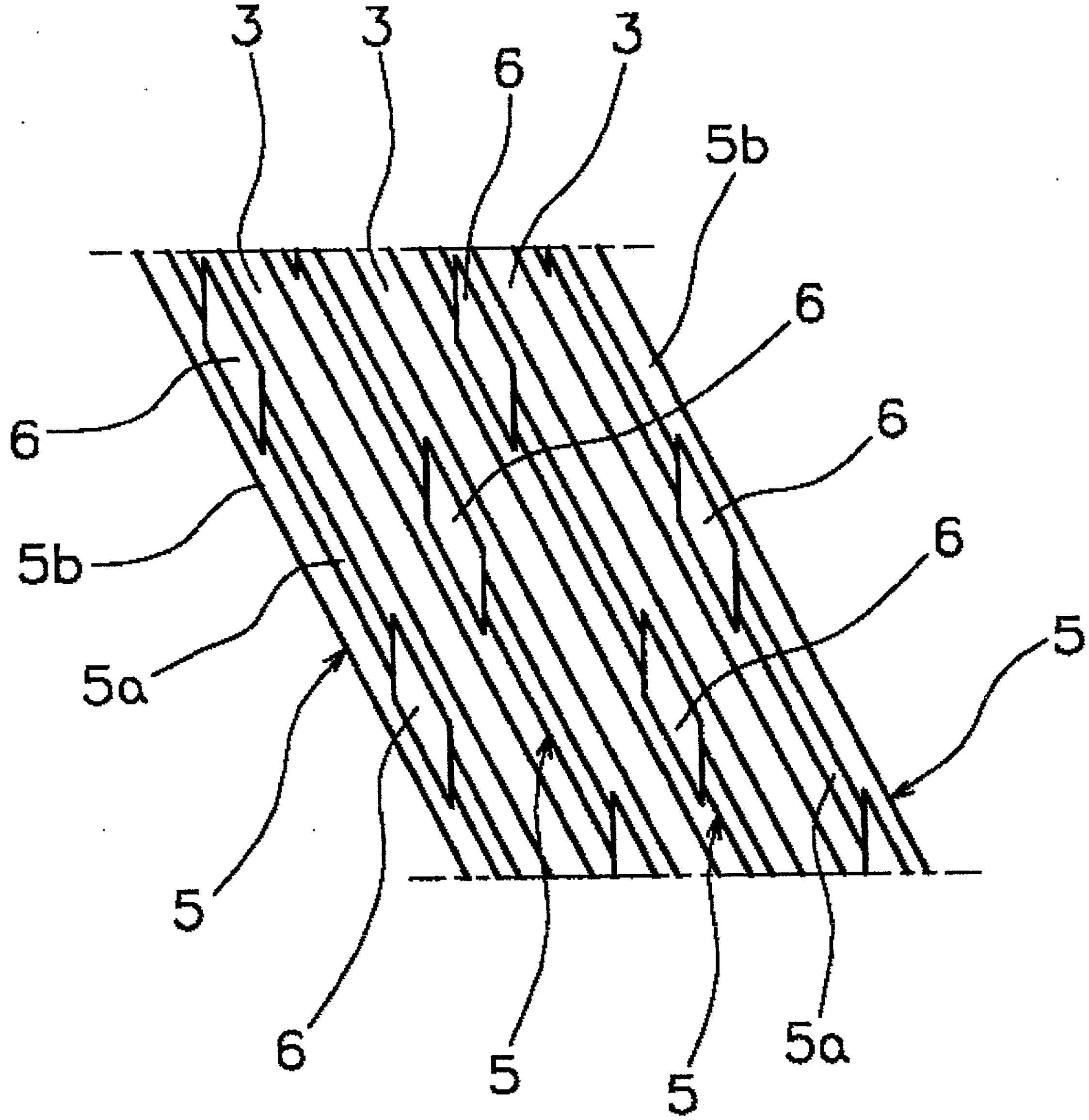


Fig. 6

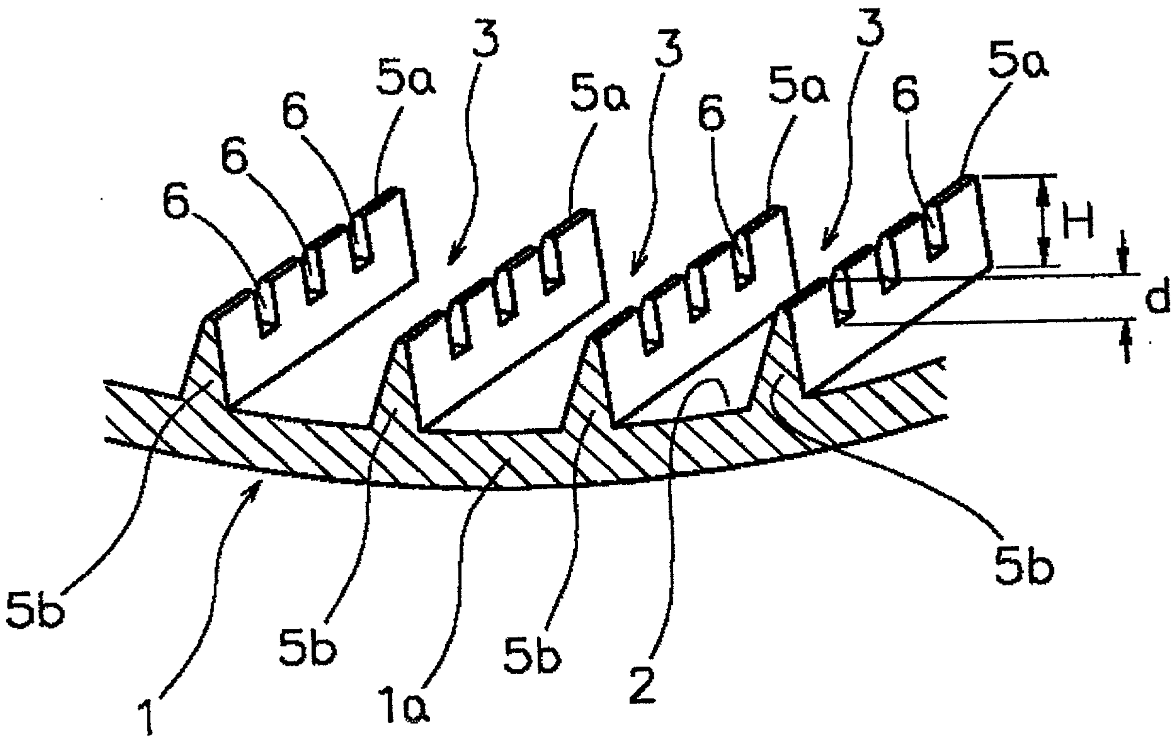


Fig. 7

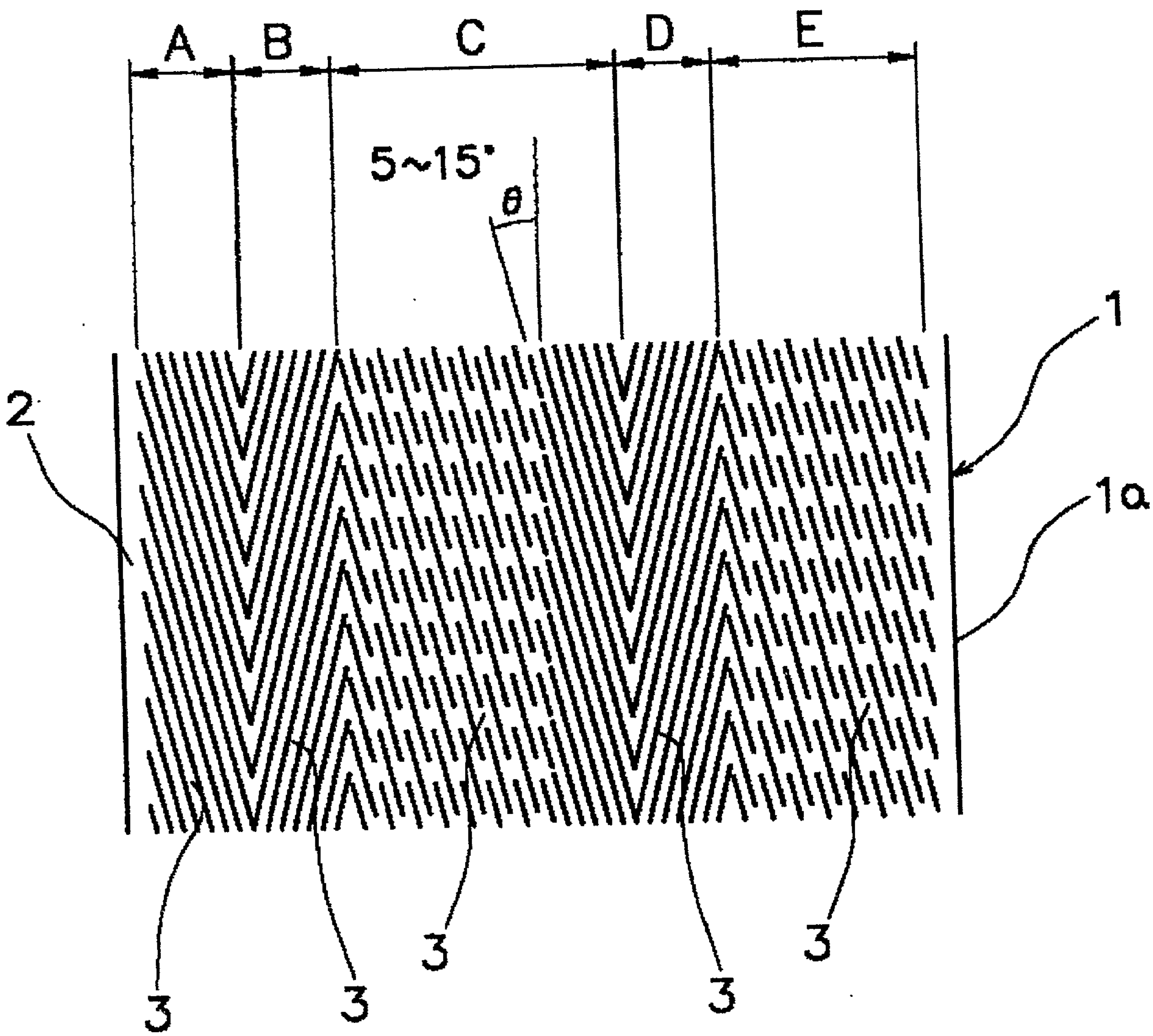


Fig.8

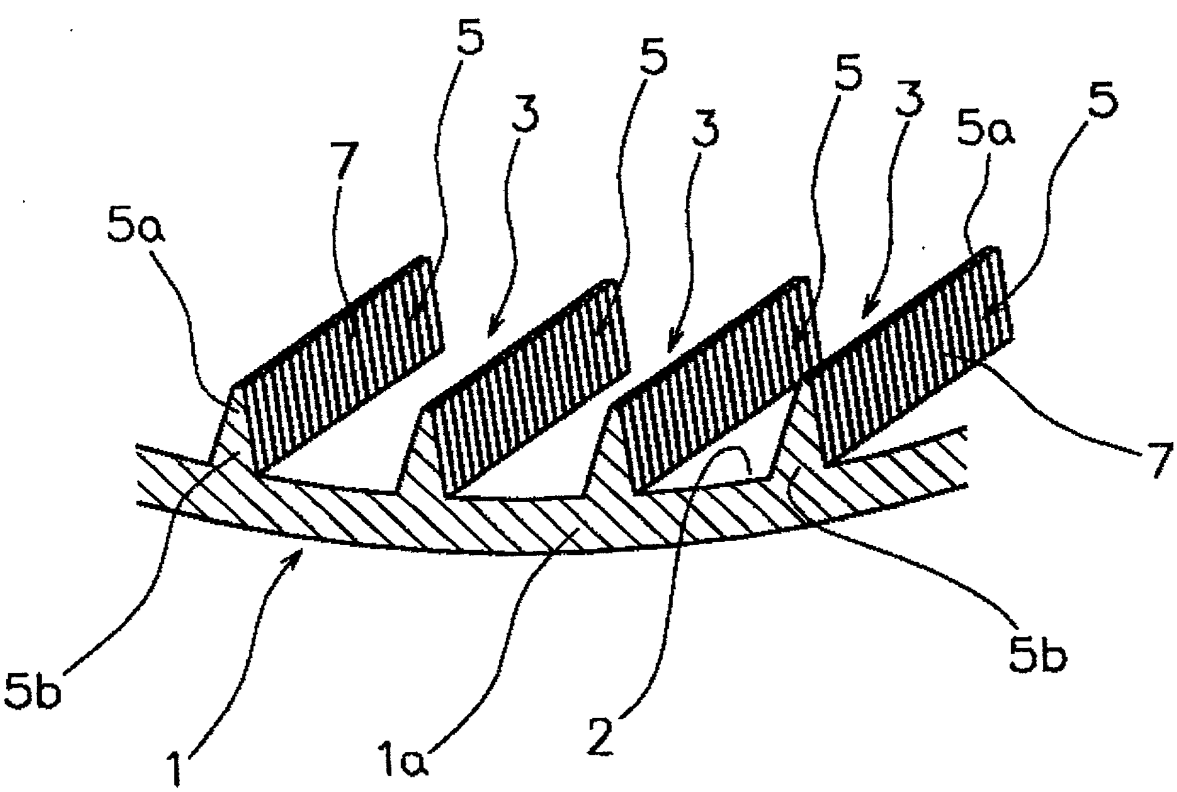
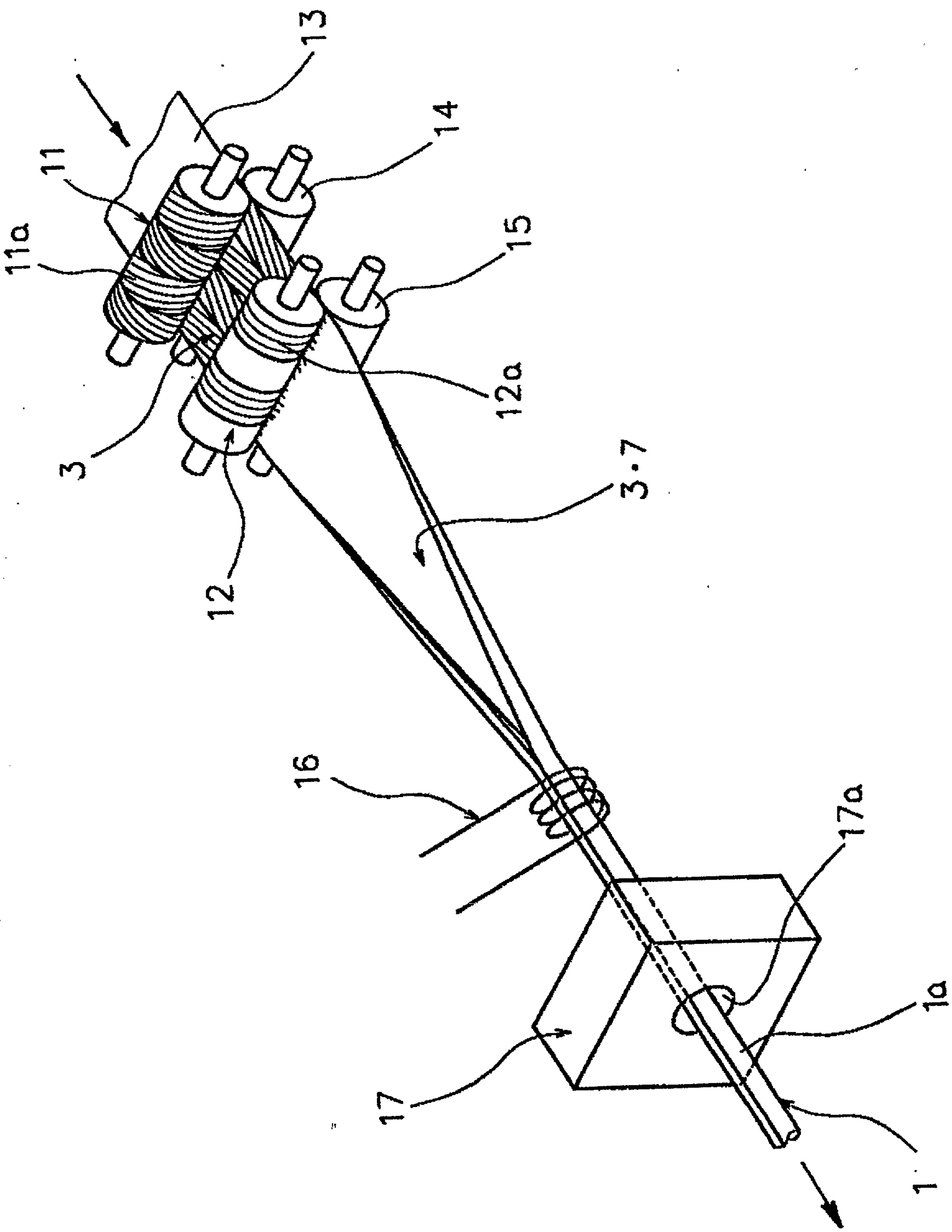


Fig.9



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As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated next to my name; that I verily believe that I am the original, first and sole inventor (if only one inventor is named below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Insert Title: → HEAT-TRANSFER PIPE WITH INTERNAL GROOVES AND MANUFACTURING METHOD AND MANUFACTURING DEVICE THEREFOR

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Prior Foreign Application(s)

(Number)	(Country)	(Month / Day / Year Filed)	Priority Claimed Yes	Priority Claimed No
11-100767	Japan	04/08/1999	☒	☐
			☐	☐
			☐	☐
			☐	☐

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* DATE OF SIGNATURE

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国際調査報告書

TITLE (I)

(54)Title: HEAT TRANSFER TUBE WITH INTERNAL GROOVES AND METHOD AND DEVICE FOR MANUFACTURING THE TUBE

(54)発明の名称 内面溝付伝熱管およびその製造方法並びに製造装置

(57) Abstract

A heat transfer tube with internal grooves, wherein multiple rows of V-shaped streaky grooves (3), (3) --- are formed in the inner peripheral surface (2) of a tube main body (1a) symmetrically with respect to the axial direction of the tube and secondary grooves (6), (6), ---, (7), (7) --- of a specified depth are formed in a part of projected streaky parts (5), (5), --- formed between the V-shaped streaky grooves to reduce a pressure loss, and the width of the multiple rows of the V-shaped streaky grooves (3), (3), --- in circumferential direction is differentiated from each other to produce a swirl component in spiral direction, whereby the flow of refrigerant in the tube can be controlled properly even when a refrigerant flow rate is small to increase a heat transfer performance as large as possible.